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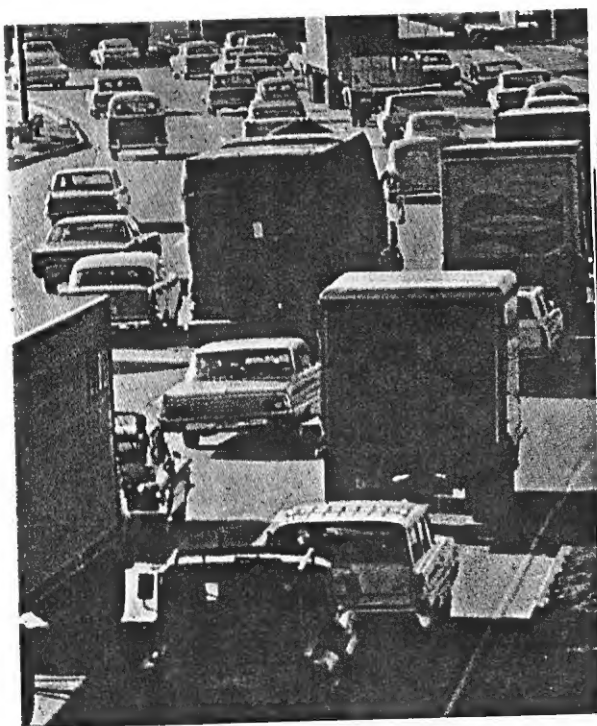
TRANSPORTATION

TRANSPORTATION takes us where we want to go, and brings us nearly everything we eat, wear, and use in daily life. Day and night, swift airliners speed passengers through the sky. Long trains roar across the countryside carrying passengers, mail, and such products as food, livestock, and coal. Automobiles, buses, and huge trucks rumble along the streets and highways. Ships steam across oceans and along lakes and rivers. Pipelines carry petroleum and natural gas across great distances.

Developments in transportation have cut travel time greatly in the past 200 years. In 1800, it often took a businessman a month to travel by sailing ship from London to New York City. Today, he can fly this distance by jet airliner in only a few hours. The airplane has made New York City closer in time to Sydney, Australia, than it was to Montreal, Canada, only a hundred years ago. Americans and Canadians can easily travel to Europe and back on a two-week vacation.

Modern transportation also makes it possible to travel in comfort. The pioneers jolted westward over rough trails in springless wagons with wooden wheels. Today, tourists ride on paved roads over the same routes in automobiles and buses with wheels that have soft, air-filled tires. Passengers on the first trains sat on hard wooden seats and often choked in clouds of smoke and dust. Food could be obtained only at wayside stations. Many of today's trains have soft, reclining seats. Air conditioning may keep the air clean and cool, and dining cars serve tasty meals.

Transportation would not be possible without communication. It depends on communication just as communication depends on transportation. Automobiles and trucks could not travel on crowded streets and highways without street signs and traffic lights. Automatic block signals and other means of communication enable railroads to operate safely. Lighthouses, lightships, bell buoys, and radio compasses provide information for ships at sea. Airplanes could not land and take off



LAND TRANSPORTATION...

From Animals to Engines



Double-Decked Horsecars, above, traveled Sixth Avenue in New York City in the 1880's. An awning protected the riders.



Kaufman-Fabry; Keyatone; Brown Bros.

Covered Wagons, upper left, were sturdy vehicles in which thousands of American pioneers rolled westward.

The Hansom Cab, left, served as the big-city taxi in the 1800's. The top-hatted driver rode above and behind his fare.

move. Perhaps they used slings or yokes hung from their shoulders to support the loads. Then man learned how to tame animals. The strong backs of horses, oxen, and other beasts could carry much heavier loads than man could, and for much greater distances.

Eventually, man began to build sleds, wagons, and other vehicles to make transportation easier and faster. But even after he had invented simple vehicles such as two-wheeled carts, he still often had to use his muscles. Ancient Roman emperors rode in chairs carried by slaves. The *sedan chair*, a similar type of vehicle, was a popular means of travel as late as the 1700's. Since then, many kinds of vehicles and machines have been developed to free man from the crushing difficulties of transportation encountered in olden times.

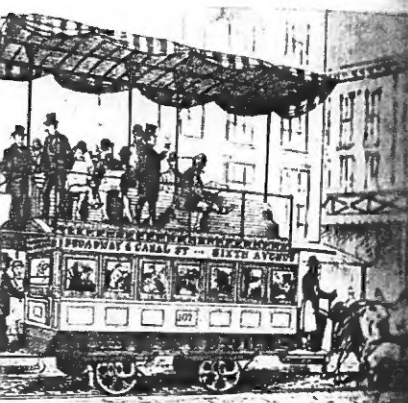
Beasts of Burden. About 8,000 years ago, man began taming animals and using them to carry his burdens. In the far north, people trained dogs to transport light loads. In the warm countries of the Mediterranean region, oxen, donkeys, and camels served man. The people of Southwestern Asia were among the first to tame the horse. The reindeer became a beast of burden in Lapland. In India, elephants were tamed. Tibetans used the yak to pull loads and to carry people. The strong water buffalo became the main beast of burden in southern Asia and on some of the Pacific islands. In Peru, people tamed the llama.

As man began taming animals, he also developed the first primitive vehicles for use with the power of beasts.

Sleds were among the first such early vehicles. These could be dragged over smooth ground as well as on snow or ice. The American Indians built a simple device called a *travois* on which to move loads. It consisted of two poles pulled by a dog and later by a horse. The Indians lashed their equipment and supplies to the sticks. See **TRAVOIS**.

The Wheel ranks as one of man's greatest discoveries. Without wheels, we would have no automobiles, trucks, trains, or many other vehicles. Some person or persons who lived near the eastern end of the Mediterranean Sea invented the wheel about 5,000 years ago. The first wheels developed from logs used as rollers to make it easier to move heavily loaded sleds. These wheels probably consisted of rough disks of wood cut from tree trunks and fastened to each end of a small roller. Such crude, solid wheels are still used in India and Java.

An Egyptian chariot built about 2000 B.C. is one of the oldest relics of wheeled vehicles ever found. It has wheels much like those of today. They consist of a hub, spokes, a rim, and wooden rim sections called *fellies* that were supported by the spokes. Chariots were the first widespread means of quick transportation and communication. Horse-drawn chariots could speed a messenger across a kingdom or launch troops in a swift attack against an enemy. The ancient Egyptians, Babylonians, and Greeks used chariots. The Greek hero Achilles rode into battle in a chariot. See **CHARIOT**; **WHEEL**.



Double-Decked Horsecars, above, traveled Sixth Avenue in New York City in the 1880's. An awning protected the riders.

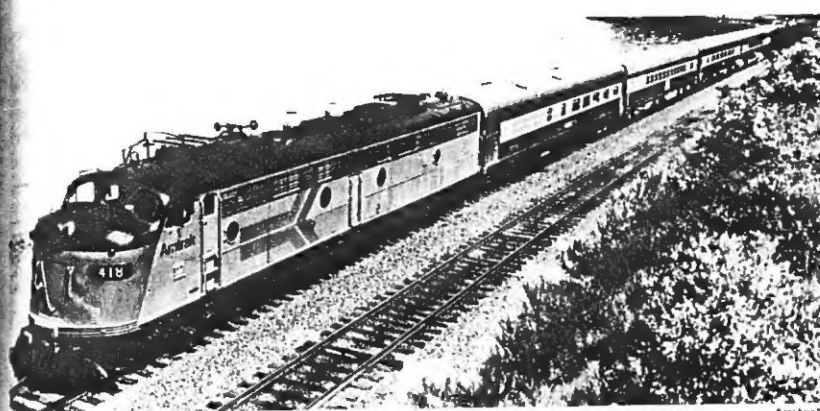
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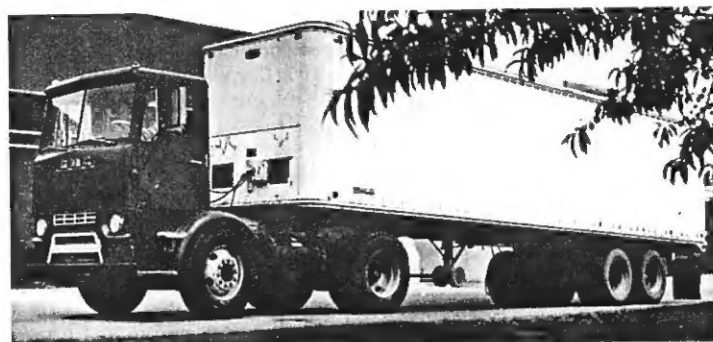
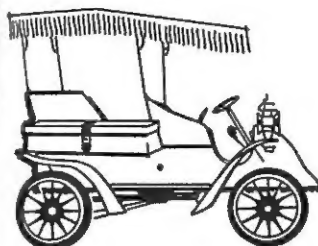
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A Gleaming Streamliner, left, pulled by a powerful diesel locomotive, carries passengers in comfort. Railroad trains also move much freight.

The 1903 Ford, an early mass-produced automobile, looked like a horse-drawn carriage called a surrey.



General Motors

A Cross-Country Truck, below, provides an efficient way of transporting freight over long distances. Its cab pulls a semitrailer that carries goods.

IMPORTANT DATES IN TRANSPORTATION

- c.6000 B.C. Man tamed the ox, the donkey, and other beasts of burden.
- c.2700 B.C. The wheel was invented in the eastern Mediterranean region.
- c.200 B.C. China became one of the first countries with an organized system of roads.
- A.D. 900's The French invented the basic parts of modern harnesses—the horse collar and traces.
- c.1000 Leif Ericson sailed west from Greenland and probably reached America.
- c.1100 Chinese and Mediterranean navigators developed the magnetic compass, which enabled sailors to navigate out of sight of land.
- c.1450 The Portuguese invented the three-masted ship, making it easier to sail against the wind.
- 1474 Emperor Frederick III of Germany developed the four-wheeled coach.
- 1522 The *Victoria*, one of Ferdinand Magellan's ships, completed the first voyage around the world.
- 1662 Blaise Pascal, a French scientist, invented the omnibus. This horse-drawn wagon gave Paris the first public mass-transportation system.
- 1769 Nicolas Cugnot, a French army officer, built one of the first steam-powered road vehicles.
- 1783 Pilâtre de Rozier, a French scientist, made the first balloon ascent in the Montgolfier brothers' lighter-than-air balloon.
- 1787 John Fitch demonstrated the first U.S. steamboat.
- 1804 Richard Trevithick of England invented the first steam railway locomotive.
- c.1815 Macadam paving for roads came into wide use.
- 1838 The *Sirius* became the first ship to cross the Atlantic Ocean entirely under steam power.
- 1840's American shipbuilders developed clipper ships, the fastest large sailing vessels.
- 1860 Jean Étienne Lenoir of France invented the first practical gas engine for a road vehicle.
- 1863 The first successful subway was built in London.
- 1869 The Suez Canal opened. The first transcontinental railroad in the United States was completed.
- 1903 The Wright brothers made the first successful airplane flight.
- 1907 Louis Bréguet and Paul Cornu made the first manned helicopter flights.
- 1914 The Panama Canal opened.
- 1919 John Alcock and Arthur Whitten-Brown of Great Britain made the first nonstop transatlantic flight.
- 1925 The first diesel locomotive began regular U.S. railroad service.
- 1939 The Heinkel Company of Germany built and flew the first jet airplane.
- 1949 The first commercial jet airliner, the De Havilland *Comet*, was unveiled in Great Britain.
- 1954 The United States Navy launched the world's first atomic-powered ship, the submarine U.S.S. *Nautilus*.
- 1959 The United States launched the first atomic-powered merchant ship, the U.S.S. *Savannah*.
- 1961 Yuri A. Gagarin of Russia made a single orbit flight around the earth in *Vostok 1* spacecraft.
- 1964 A train that can travel 125 mph (201 kph) began service between Tokyo and Osaka, Japan.
- 1968 Russia flew the world's first supersonic transport (SST), the Tupolev Tu-144.
- 1970 Pan American World Airways, Inc., began commercial flights of a 362-passenger Boeing 747 jet.
- 1971 Amtrak, a private corporation established by the U.S. Congress in 1970, took over the operation of most passenger trains in the United States.
- 1972 The first phase of the Bay Area Rapid Transit System (BART) opened near San Francisco. It was the first all-new U.S. mass transit system built since 1909.

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Boats and Ships. Man learned how to travel on water about the same time that he began taming animals. The first boat was probably a fallen log that early man used to ferry himself across a stream. Perhaps he straddled the log and paddled with his hands, or pushed the log through the water with a pole. Then man learned how to lash logs together to make rafts. Such rafts were often too heavy to be poled upstream against the current. In time, man discovered how to hollow out logs to make dugout canoes that he could paddle against the current. Later, he stretched bark over a framework of wood to make a lighter craft, the canoe.

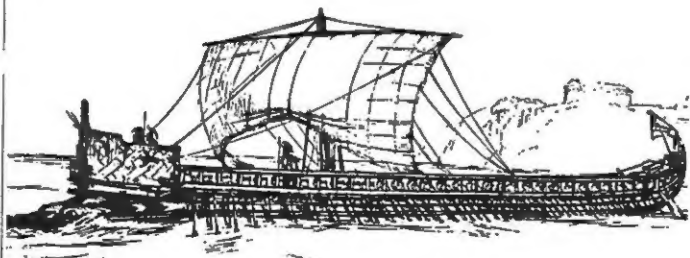
The next big step in water transportation was the development of boats and ships propelled by oars and sails. This came about the same time as the wheel. The ancient Egyptians sailed up and down the Nile River in boats at least 5,000 years ago. They developed a craft made of planks fastened around a wooden framework much like the ships of today. The Phoenicians, who lived along the eastern shore of the Mediterranean Sea, used *galleys*. These boats had a row of oars extending from front to back on each side. Later, the Phoenicians built *biremes*, or ships with two rows of oars on each side, one above the other (see *GALLEY; PHOENICIA*). Finally, early boatbuilders developed the *trireme*, a craft with three banks of oars on each side (see *TRIEME*). Triremes were much faster than any earlier ships, but it took as many as 200 slaves to pull the oars. These early

vessels also usually had a single sail suspended from a mast. This could be used only to sail with the wind.

Roads. Early man lived in a land unmarked by roads or trails. As he wandered about in search of food, he had to hack his way through thick forests, climb high mountains, and wade through dangerous swamps and deep streams. Gradually, men began to seek the easiest routes, and to mark trails. Later, they widened and smoothed the trails so the routes could be used by pack animals and carts and wagons.

At first, men improved trails only in places where they lived. But, as empires developed, rulers learned that they had to build systems of roads in order to control and govern large areas of land. Roads made it possible to send messengers, mail, government officials, and troops throughout an empire. China had a system of roads as early as 2700 B.C. After 1122 B.C., the Chou dynasty of Chinese rulers founded perhaps the first organization to operate and repair roads as highway departments do today.

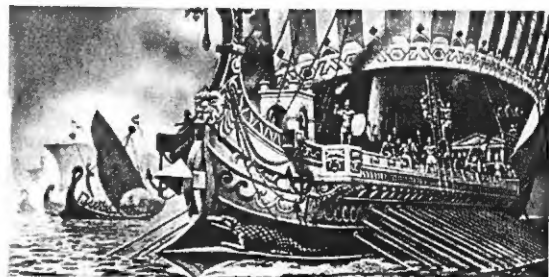
The Romans built the first great system of paved roads. They made roads with stone surfaces, and constructed arched stone bridges across streams. These roads linked many parts of Western Europe, and parts of Asia Minor and North Africa. One of the most famous of these roads was the Appian Way (see *APPIAN WAY*). After the Roman Empire fell in the A.D. 400's, most of this road system disintegrated. But parts of it formed the beginnings of later systems. Some ancient Roman roads are still used. See *ROADS AND HIGHWAYS*.



WATER TRANSPORTATION

From Galleys to Supertankers

Galleys Propelled by Oars, left, carried the ancient Greeks on voyages on the Mediterranean Sea.



Smithsonian Institution; Brown Bros.

Roman Triremes, above, were galleys with three banks of oars. Triremes were the most powerful warships of their day.

Three-Masted Sailing Ships, like the replica of Columbus' Santa Maria, left, made early voyages across the world's oceans.

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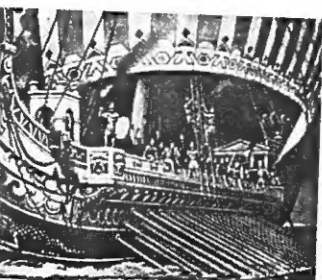
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TRANSPORTATION

Keys to Supertankers

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In South America, the Inca Indians of Peru built a system of stone-surfaced roads along the Pacific side of the Andes Mountains. This system stretched nearly 10,000 miles (4,800 kilometers), and was a marvel of engineering. See INCA.

The Middle Ages. People rarely traveled long distances on land during the Middle Ages. The few roads that were built had deep ruts that made travel uncomfortable. In spring and fall, mud often made the roads impassable. Pack horses served as the main means of transporting goods. Not until the A.D. 900's, when the French invented the horse collar and traces, was a type of harness developed with which horses could haul heavy loads. Until then, people had used various arrangements of straps which cut into the horse's flesh if the load was heavy. The horse collar put the weight of the pull on the animal's shoulders and chest without cutting. In spite of this development, there were few two-wheeled carts until near the end of the Middle Ages in the 1300's and 1400's. In 1474, Emperor Frederick III of Germany introduced the four-wheeled coach. By the 1500's, stagecoaches had come into use and regular stagecoach lines were established. See STAGECOACH.

The big transportation events of the Middle Ages took place on water. The magnetic compass, developed by Chinese and Mediterranean navigators, came into use. Ships became larger and more seaworthy. About 1450, the Portuguese originated the three-masted ship. This vessel harnessed more wind power, but had sails small enough for sailors to handle. The additional sails

TRANSPORTATION

provided by three masts also made it possible to tack, or maneuver, ships against the wind. During this period, Christopher Columbus made his famous voyage to America. Other explorers sailed around Africa, and, in 1522, one of Ferdinand Magellan's ships, the *Victoria*, completed the first voyage around the world.

The Steam Age. The invention of the steam engine during the 1700's ushered in a new era in transportation. Steam gave man a vast new source of power. Until then, he had depended on the power of his muscles, or on animal, water, and wind power. James Watt of Scotland developed one of the first steam engines during the 1760's, and inventors soon tried to use it in transportation. As early as 1769, Nicolas Cugnot, a French army officer, built a three-wheeled, steam-driven tractor.

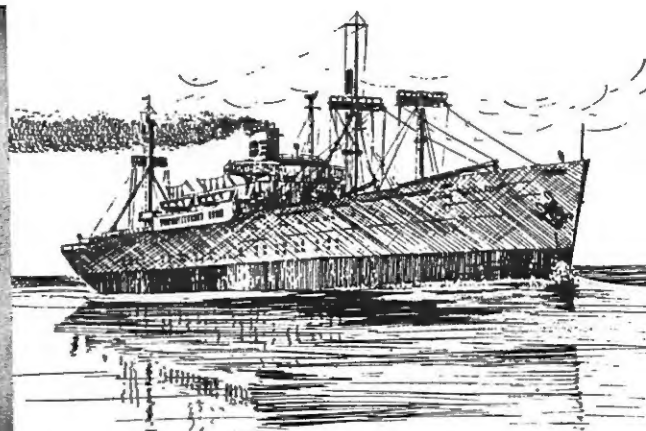
But the first big advance in the use of steam power came in water transportation. John Fitch, an American inventor, demonstrated one of the first successful steamboats in 1787. The craft's steam engine operated a series of paddles on each side of the boat. In 1807, Robert Fulton of the United States developed the first commercially successful steamboat, the *Clermont*. On Fulton's ship, the steam engine operated a paddle wheel. In 1836, a Swedish-American inventor, John Ericsson, developed the screw propeller with blades. This propeller worked much more efficiently than paddle wheels.

The second big advance in the use of steam power for transportation took place on land. Horse-drawn rail-

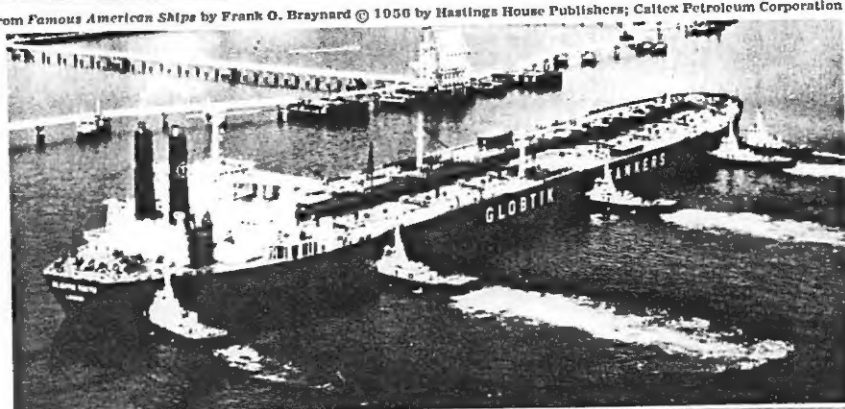


Clipper Ships of the 1800's, such as the one above, were the fastest sailing ships ever built. They could go 20 knots with a favorable wind.

Supertankers, such as the vessel at the right, are the largest ships afloat. They carry much of the world's oil from continent to continent.



Modern Steamships, such as this combination cargo-passenger vessel, above, carry freight and travelers.



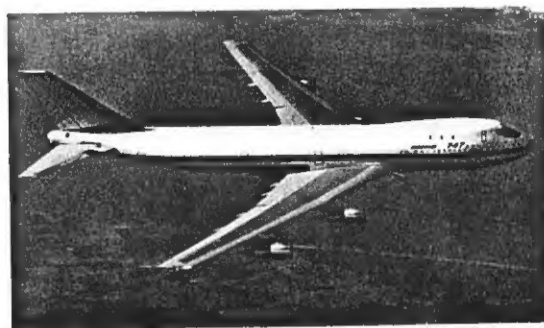
Brown Bros.: from *Famous American Ships* by Frank O. Braynard © 1956 by Hastings House Publishers; Caltex Petroleum Corporation

AIR TRANSPORTATION

From Balloons to Space Rockets



Balloons carried man aloft on his first air trips. In 1785, the balloon, left, made the first air crossing of the English Channel in two hours.

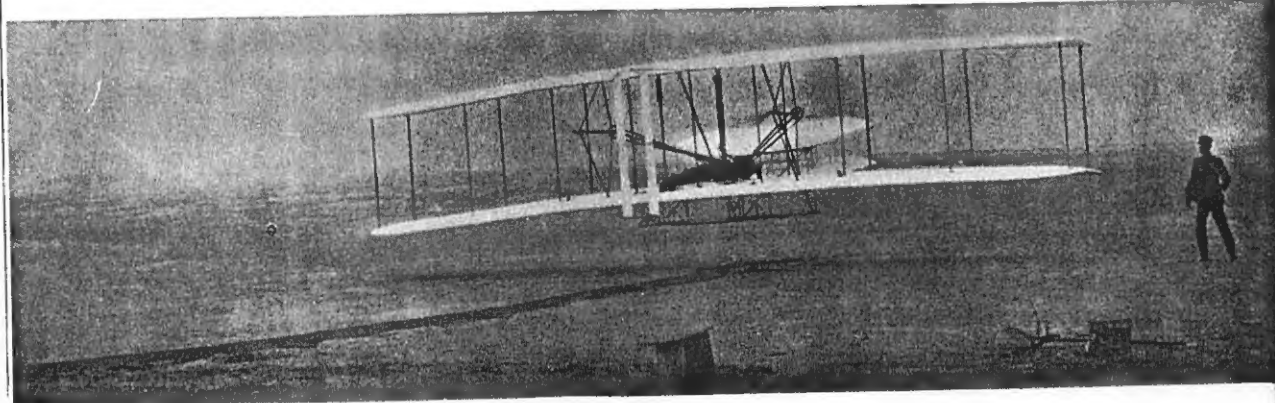


The Boeing Company

A Boeing 747 Jet can fly as far as 6,700 miles (10,800 kilometers) at a cruising speed of 600 miles (966 kilometers) per hour.

The First Airplane Flight, below, carried Orville Wright 120 feet (37 meters) in 1903. A 12-horsepower (9-kilowatt) engine powered the tiny craft.

Bettmann Archive; Culver



road cars were being used in England before 1800, mostly to haul coal from mines to docks. Richard Trevithick of England invented the steam locomotive in 1804, and by 1816 some were being used on mine railways. But steam locomotives did not come into general use for passenger and freight transportation until after 1825. The first railway for public transportation opened in Great Britain that year.

From 1825 until the development of diesel power in the 1900's, steam served as the main source of power in transportation. The steam locomotive was perfected so rapidly that speeds of 60 miles (97 kilometers) per hour were reached before 1850. Between 1850 and 1900, the steam railroad was almost the only method of travel between cities in the more developed parts of the world. Steam railroads made it possible for man to open up the great interiors of the continents by providing a cheap, fast, and powerful means of transportation.

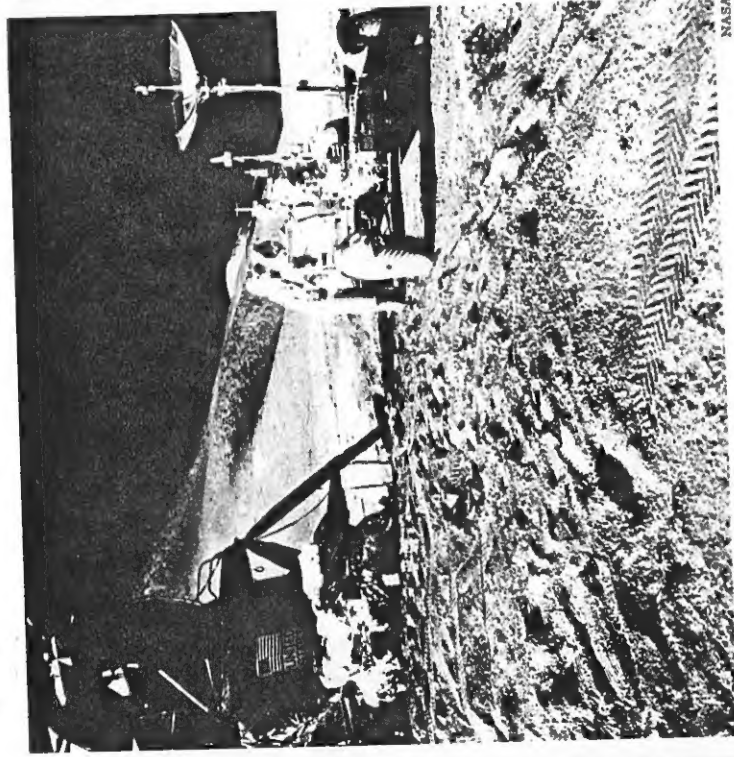
Electricity provided a new source of power for transportation in the late 1800's. It became particularly useful in providing power for streetcar systems in cities, where the distances to be traveled were fairly short. Each streetcar had its own motor and drew electric power from overhead lines connected to a central electric-power plant. The first commercial electric railroad was put into operation in Germany in 1881. Engineers soon adapted the electric railroad to subways and elevated lines.

The Automobile and Airplane are two of the most important conveyances ever developed. Both depend on the internal-combustion engine, which burns gasoline or other petroleum fuels. The steam engine was too bulky and heavy for cars and aircraft, and the electric motor needed a steady source of electricity. This could be supplied only by heavy batteries which had to be frequently recharged.

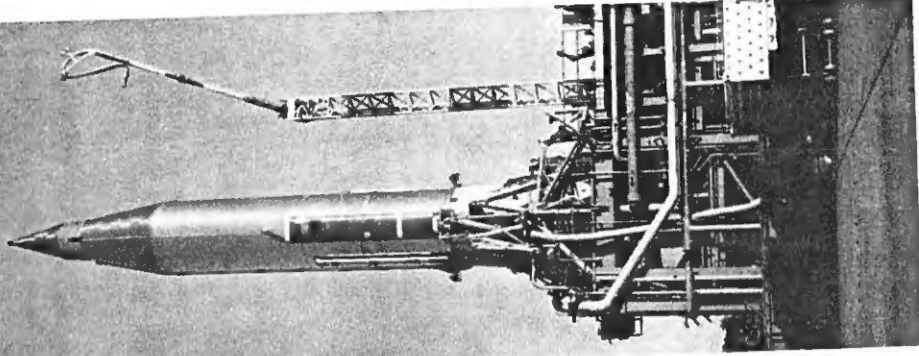
Jean Étienne Lenoir, a Frenchman, built the first gas engine for a land vehicle in 1860. By 1900, the automobile had been born, and, in 1903, the Wright brothers made the first successful powered airplane flight. The internal-combustion engine also made possible the tractor, which became the most important source of power on farms. See TRACTOR.

The automobile changed the people's way of life in many lands. It provided cheap, fast transportation that many persons could afford. This made possible the far-flung suburbs that clustered around the larger American and Canadian cities. With an automobile, a worker could live far from his job. Motoring became a favorite form of recreation. Families could make weekend trips to visit friends and relatives, and spend vacations in distant parts of the country. The automobile also led to the development of trucks, which became an important means of moving goods shipped in small quantities.

The airplane provides man's swiftest means of transportation. In an airplane, people can reach any spot on



Apollo Space Travelers landed on the moon in a lunar module, left. To explore the surface of the moon, the astronauts traveled in a small, electrically powered vehicle called a lunar rover, right.



Dept. of Defense

A Giant Atlas Missile, one of the world's first space vehicles, stood poised shortly before it soared into orbit around the earth in 1958.

earth in a matter of hours or days. In remote regions, jungles, mountains, or snow and ice make land transportation difficult. Airplanes furnish a fast, sure means of transporting supplies and passengers in these regions.

Diesel Power. Rudolf Diesel, a German engineer, invented the diesel engine in 1897. This is a kind of internal-combustion engine that burns oil. A diesel engine weighs more than a gasoline engine, but it costs less to operate. A United States railroad placed a diesel locomotive into regular service for the first time in 1925. Today, diesel locomotives have replaced all U.S. steam locomotives in regular service. Diesel engines also became an important source of power in trucks, tractors, and ships. Most river and harbor tugboats, and some ocean-going ships and lake vessels, have diesel engines. See **DIESEL ENGINE**.

Transportation Today. There are about 748,000 miles (1,204,000 kilometers) of railroad track in the world today. The number of automobiles, trucks, and buses in the world totals about 329 million. Transportation is so important that \$1 of every \$7 spent in the United States buys some kind of transportation service. From 1890 to 1930, freight transportation almost doubled every 10 years. From 1930 to 1957, it more than doubled again. Today, the United States has about 14 times as much freight transportation as it had in 1890. Russia's multiplied 12 times since 1913.

A process called *containerization* has greatly improved

freight transportation. Containerization involves placing freight in huge containers that may be as large as railroad cars. After shippers put their goods into the containers, the containers are hauled by one or more types of transportation to the customer. For example, a loaded container may be hauled inland by truck and rail, and then carried by ship to foreign markets.

With containerization, freight need be handled only twice—when it is loaded into the container and later unloaded at its destination. The process thus greatly reduces labor costs. Enormous *container ships* have replaced older cargo ships on many major trade routes. These ships have compartments into which hundreds of containers can fit easily and securely. In an older method of containerization called railroad *piggyback*, manufacturers load their goods into a truck trailer. The loaded trailer is then put on a railroad flatcar for shipping.

The jet engine, which burns kerosene and ejects a stream of hot gases, was invented in the 1930's. It made jet airplanes twice as fast as other aircraft and cheaper to operate. Many military airplanes now fly faster than the speed of sound. Nuclear power, first used in submarines in the 1950's, has also been developed for merchant ships. A new propeller, called the *superavitating propeller*, has been developed. It may double the speed of ships (see **PROPELLER** [Marine Propellers]).

Urban planners have developed ways to make public